Amendments to the Claims

This listing of claims replaces all prior versions, and listings, of claims in this application.

Listing of Claims:

1. (Currently Amended) An image processor for use in drawing an image to a memory having a two-dimensional matrix of pixel drawing regions, each of the pixel drawing regions representing a single pixel in the image, said image processor comprising:

a plurality of relative orientation detection filters each representing a distinguishing feature of a relative orientation of an edge segment to be drawn to the memory;

drawing means for drawing the image to the memory or a buffer having the same structure as the memory;

detection means for

automatically detecting a connected sequence of pixel drawing regions making up an edge in the image drawn by said drawing means by applying an edge extraction filter, and

detecting the relative orientation of the connected sequence of pixel drawing regions by means of

selecting out ~~one~~ a predetermined number of relative orientation detection ~~filter~~ filters each representing ~~the~~ a distinguishing feature that is ~~closest~~ closer to the distinguishing feature of the connected sequence of pixel drawing regions in question, and

performing interpolation with the relative orientations specified by the selected relative orientation detection filters; and

smoothing means for smoothing a pixel value of each pixel in the connected sequence of pixel drawing regions on the edge using smoothing coefficients, the smoothing coefficients being either computed depending on the relative orientation detected by said detection means or obtained from outside,

wherein each of said plurality of relative orientation detection filters is a two-dimensional matrix of predetermined orientation coefficients, the orientation coefficients including zero orientation coefficients each having a value of zero and non-zero orientation coefficients each having a value other than zero, the non-zero orientation coefficients being aligned relative to each other in a predetermined direction,

said detection means

performing convolution of all orientation coefficients contained in said relative orientation detection filters, with each pixel value of the connected sequence of pixel drawing regions making up the edge,

selecting out a predetermined number of relative orientation detection filters for which their respective convolution results in a single direction exceed a predetermined threshold value and yield the largest result, the second largest result, and the third largest result, respectively, as the relative orientation filters having their respective distinguishing features that are closer to the distinguishing feature in the subject direction, and

distributing, using interpolation, the relative orientations specified by the selected relative orientation detection filters, thereby determining one relative orientation.

2. (Canceled)

3. (Currently Amended) The image processor as claimed in Claim ~~2~~ 1, wherein said smoothing means has a plurality of smoothing filters each containing predetermined smoothing coefficients, the smoothing coefficients including zero smoothing coefficients each having a value of zero and non-zero smoothing coefficients each having a value other than zero, said smoothing filter being linked to one of said relative orientation detection filters in such a manner that the non-zero smoothing coefficients being arranged in the same pattern as the non-zero orientation coefficients in said relative orientation detection filters,

said smoothing means

identifying, in response to the selection of the relative orientation detection filter by said detection means, the smoothing filter that is linked to the selected relative orientation detection filter,

performing convolution of the smoothing coefficients of the identified smoothing filter individually with each pixel value of the connected sequence of pixel drawing regions making up the edge, and

replacing a target pixel value in the connected sequence of pixel drawing regions with the convolution result, thereby smoothing the focused pixel value.

4. (Canceled)

5. (Currently Amended) ~~The image processor as claimed in Claim 4,~~ An image processor for use in drawing an image to a memory having a two-dimensional matrix of pixel drawing regions, each of the pixel drawing regions representing a single pixel in the image, said image processor comprising:

a plurality of relative orientation detection filters each representing a distinguishing feature of a relative orientation of an edge segment to be drawn to the memory;

drawing means for drawing the image to the memory or a buffer having the same structure as the memory;

detection means for

detecting a connected sequence of pixel drawing regions making up an edge in the image drawn by said drawing means, and

detecting the relative orientation of the connected sequence of pixel drawing regions by means of

selecting out a predetermined number of relative orientation detection filters each representing a distinguishing feature that is closer to the distinguishing feature of the connected sequence of pixel drawing regions, and

performing interpolation with the relative orientations specified by the selected relative orientation detection filters; and

smoothing means for smoothing a pixel value of each pixel in the connected sequence of pixel drawing regions on the edge using smoothing coefficients, the smoothing coefficients being

either computed depending on the relative orientation detected by said detection means or obtained from outside,

wherein each of said plurality of relative orientation detection filters is a two-dimensional matrix of predetermined orientation coefficients, the orientation coefficients including zero orientation coefficients each having a value of zero and non-zero orientation coefficients each having a value other than zero, the non-zero orientation coefficients being aligned relative to each other in a predetermined direction;

said detection means

performing convolution of all orientation coefficients contained in said relative orientation detection filters, with each pixel value of the connected sequence of pixel drawing regions making up the edge,

selecting out a predetermined number of relative orientation detection filters for which their respective convolution results in a single direction exceed a predetermined threshold value and yield the largest result, the second largest result, and the third largest result, respectively, as the relative orientation filters having their respective distinguishing features that are closer to the distinguishing feature in the subject direction, and

distributing, using interpolation, the relative orientations specified by the selected relative orientation detection filters, thereby determining one relative orientation.

6. (Previously Presented) The image processor as claimed in Claim 1, wherein said smoothing means

generates a smoothing filter which is a matrix of predetermined smoothing coefficients, the smoothing coefficients including zero smoothing coefficients each having a value of zero and non-zero smoothing coefficients each having a value other than zero, the non-zero smoothing coefficients in the generated smoothing filter being arranged in the direction of the relative orientation detected by said detection means,

performs convolution of the smoothing coefficients of that smoothing filter individually with each pixel value of the connected sequence of pixel drawing regions making up the edge, and

replaces a target pixel value in the connected sequence of pixel drawing regions with the convolution result, thereby smoothing the focused pixel value.

7. (Original) The image processor as claimed in Claim 5, wherein

said smoothing filter having a two-dimensional matrix of smoothing coefficients, the smoothing coefficients including zero smoothing coefficients each having a value of zero and non-zero smoothing coefficients each having a value other than zero, the non-zero smoothing coefficients more distant from the center of the filter having smaller non-zero values, the non-zero smoothing coefficients being arranged in the direction of the detected relative orientation,

said smoothing means performing convolution of all smoothing coefficients contained in the smoothing filter in question, with a target pixel in the connected sequence of pixel drawing regions making up the edge in such a manner that the center of the smoothing filter is matched with the target pixel.

8. (Original) The image processor as claimed in Claim 7, wherein the smoothing coefficients in each smoothing filter are normalized so that the smoothing filters with different patterns of arrangement of the smoothing coefficients are on the same scale.

9. (Original) The image processor as claimed in Claim 5, wherein said smoothing means performs smoothing only when the relative orientation detected by said detection means forms a predetermined angle with respect to the horizontal or vertical axis of the matrix and when at least a predetermined number of pixel drawing regions having the same relative orientation are arranged in sequence.

10. (Currently Amended) An image processing method performed by a processor having access to a memory to which an image is drawn and a plurality of relative orientation detection filters, the memory having a two-dimensional matrix of pixel drawing regions, each of the pixel drawing regions representing a single pixel in the image, each of the relative orientation detection filters representing a distinguishing feature of a relative orientation of an edge segment to be drawn to the memory, said method comprising the steps of:

(1) drawing the image to the memory or a buffer having the same structure as the memory without performing anti-aliasing operation;

(2) automatically detecting a connected sequence of pixel drawing regions making up an edge in the drawn image by applying an edge extraction filter;

(3) detecting the relative orientation of the connected sequence of pixel drawing regions by ~~means of~~

selecting out ~~one~~ a predetermined number of relative orientation detection ~~filter~~ filters each representing ~~the~~ a distinguishing feature that is ~~closest~~ closer to the distinguishing feature of the connected sequence of pixel drawing regions in question, and

performing interpolation with the relative orientations specified by the selected relative orientation detection filters; and

(4) generating a smoothing filter which is a matrix of smoothing coefficients, the smoothing coefficients including zero smoothing coefficients each having a value of zero and non-zero smoothing coefficients each having a value other than zero, the non-zero smoothing coefficients in the generated smoothing filter being arranged in the direction of the relative orientation, or alternatively, obtaining the smoothing filter that has been prepared previously;

performing convolution of the smoothing coefficients of that smoothing filter individually with each pixel value of the connected sequence of pixel drawing regions; and

replacing a target pixel value in the connected sequence of pixel drawing regions with the convolution result, thereby smoothing the focused pixel value, thereby anti-aliasing the image having the edge including the target pixel value,

wherein each of said plurality of relative orientation detection filters is a two-dimensional matrix of predetermined orientation coefficients, the orientation coefficients including zero orientation coefficients each having a value of zero and non-zero orientation coefficients each having a value other than zero, the non-zero orientation coefficients being aligned relative to each other in a predetermined direction,

wherein detecting the relative orientation further comprises

performing convolution of all orientation coefficients contained in said relative orientation detection filters, with each pixel value of the connected sequence of pixel drawing regions making up the edge,

selecting out a predetermined number of relative orientation detection filters for which their respective convolution results in a single direction exceed a predetermined threshold value and yield the largest result, the second largest result, and the third largest result, respectively, as the relative orientation filters having their respective distinguishing features that are closer to the distinguishing feature in the subject direction, and

distributing, using interpolation, the relative orientations specified by the selected relative orientation detection filters, thereby determining one relative orientation.

11. (Currently Amended) An image processing method performed by a processor having access to a memory to which an image is drawn and a plurality of relative orientation detection filters, the memory having a two-dimensional matrix of pixel drawing regions, each of the pixel drawing regions representing a single pixel in the image, each of the relative orientation detection filters representing a distinguishing feature of a relative orientation of an edge segment to be drawn to the memory, said method comprising the steps of:

(1) drawing the image to the memory or a buffer having the same structure as the memory without performing anti-aliasing operation;

(2) detecting a connected sequence of pixel drawing regions making up an edge in the drawn image;

(3) detecting the relative orientation of the connected sequence of pixel drawing regions by ~~means of~~

selecting out a plurality of relative orientation detection filters each representing a distinguishing feature that is ~~close~~ closer to the distinguishing feature of the connected sequence of pixel drawing regions, and

performing interpolation with the relative orientations specified by the selected relative orientation detection filters; and

(4) generating a smoothing filter which is a matrix of smoothing coefficients, the smoothing coefficients including zero smoothing coefficients each having a value of zero and non-zero smoothing coefficients each having a value other than zero, the non-zero smoothing coefficients in the generated smoothing filter being arranged in the direction of the relative orientation, or alternatively, obtaining the smoothing filter that has been prepared previously;

performing convolution of the smoothing coefficients of that smoothing filter individually with each pixel value of the connected sequence of pixel drawing regions; and

replacing a target pixel value in the connected sequence of pixel drawing regions with the convolution result, thereby smoothing the focused pixel value, thereby anti-aliasing the image having the edge including the target pixel value,

wherein each of said plurality of relative orientation detection filters is a two-dimensional matrix of predetermined orientation coefficients, the orientation coefficients including zero orientation coefficients each having a value of zero and non-zero orientation coefficients each having a value other than zero, the non-zero orientation coefficients being aligned relative to each other in a predetermined direction,

wherein detecting the relative orientation further comprises

performing convolution of all orientation coefficients contained in said relative orientation detection filters, with each pixel value of the connected sequence of pixel drawing regions making up the edge,

selecting out a predetermined number of relative orientation detection filters for which their respective convolution results in a single direction exceed a predetermined threshold value and yield the largest result, the second largest result, and the third largest result, respectively, as the relative orientation filters having their respective distinguishing features that are closer to the distinguishing feature in the subject direction, and

distributing, using interpolation, the relative orientations specified by the selected relative orientation detection filters, thereby determining one relative orientation.

12. (Currently Amended) A computer program recorded on a computer-readable recording medium and configured to be executed by a processor having access to a memory to which an image is drawn and a plurality of relative orientation detection filters, the memory having a two-dimensional matrix of pixel drawing regions, each of the pixel drawing regions representing a single pixel in the image, each of the relative orientation detection filters representing a distinguishing feature of a relative orientation of an edge segment to be drawn to the memory, said computer program being for the processor to perform the operations of:

(1) drawing the image to the memory or a buffer having the same structure as the memory without performing anti-aliasing operation;

(2) automatically detecting a connected sequence of pixel drawing regions making up an edge in the drawn image by applying an edge extraction filter;

(3) detecting the relative orientation of the connected sequence of pixel drawing regions by ~~means of~~

selecting out ~~one~~ a predetermined number of relative orientation detection ~~filter~~ filters each representing ~~the~~ a distinguishing feature that is ~~closest~~ closer to the distinguishing feature of the connected sequence of pixel drawing regions in question, and

performing interpolation with the relative orientations specified by the selected relative orientation detection filters; and

(4) generating a smoothing filter which is a matrix of smoothing coefficients, the smoothing coefficients including zero smoothing coefficients each having a value of zero and non-zero smoothing coefficients each having a value other than zero, the non-zero smoothing coefficients in the generated smoothing filter being arranged in the direction of the relative orientation, or alternatively, obtaining the smoothing filter that has been prepared previously;

performing convolution of the smoothing coefficients of that smoothing filter individually with each pixel value of the connected sequence of pixel drawing regions; and

replacing a target pixel value in the connected sequence of pixel drawing regions with the convolution result, thereby smoothing the focused pixel value, thereby anti-aliasing the image having the edge including the target pixel value,

wherein each of said plurality of relative orientation detection filters is a two-dimensional matrix of predetermined orientation coefficients, the orientation coefficients including zero

orientation coefficients each having a value of zero and non-zero orientation coefficients each having a value other than zero, the non-zero orientation coefficients being aligned relative to each other in a predetermined direction,

wherein detecting the relative orientation further comprises

performing convolution of all orientation coefficients contained in said relative orientation detection filters, with each pixel value of the connected sequence of pixel drawing regions making up the edge,

selecting out a predetermined number of relative orientation detection filters for which their respective convolution results in a single direction exceed a predetermined threshold value and yield the largest result, the second largest result, and the third largest result, respectively, as the relative orientation filters having their respective distinguishing features that are closer to the distinguishing feature in the subject direction, and

distributing, using interpolation, the relative orientations specified by the selected relative orientation detection filters, thereby determining one relative orientation.

13. (Currently Amended) A computer program recorded on a computer-readable recording medium and configured to be executed by a processor having access to a memory to which an image is drawn and a plurality of relative orientation detection filters, the memory having a two-dimensional matrix of pixel drawing regions, each of the pixel drawing regions representing a single pixel in the image, each of the relative orientation detection filters representing a

distinguishing feature of a relative orientation of an edge segment to be drawn to the memory, said computer program being for the processor to perform the operations of:

(1) drawing the image to the memory or a buffer having the same structure as the memory without performing anti-aliasing operation;

(2) detecting a connected sequence of pixel drawing regions making up an edge in the drawn image;

(3) detecting the relative orientation of the connected sequence of pixel drawing regions by ~~means of~~

selecting out a plurality of relative orientation detection filters each representing a distinguishing feature that is ~~close~~ closer to the distinguishing feature of the connected sequence of pixel drawing regions, and

performing interpolation with the relative orientations specified by the selected relative orientation detection filters; and

(4) generating a smoothing filter which is a matrix of smoothing coefficients, the smoothing coefficients including zero smoothing coefficients each having a value of zero and non-zero smoothing coefficients each having a value other than zero, the non-zero smoothing coefficients in the generated smoothing filter being arranged in the direction of the relative orientation, or alternatively, obtaining the smoothing filter that has been prepared previously;

performing convolution of the smoothing coefficients of that smoothing filter individually with each pixel value of the connected sequence of pixel drawing regions; and

replacing a target pixel value in the connected sequence of pixel drawing regions with the convolution result, thereby smoothing the focused pixel value, thereby anti-aliasing the image having the edge including the target pixel value,

wherein each of said plurality of relative orientation detection filters is a two-dimensional matrix of predetermined orientation coefficients, the orientation coefficients including zero orientation coefficients each having a value of zero and non-zero orientation coefficients each having a value other than zero, the non-zero orientation coefficients being aligned relative to each other in a predetermined direction,

wherein detecting the relative orientation further comprises

performing convolution of all orientation coefficients contained in said relative orientation detection filters, with each pixel value of the connected sequence of pixel drawing regions making up the edge,

selecting out a predetermined number of relative orientation detection filters for which their respective convolution results in a single direction exceed a predetermined threshold value and yield the largest result, the second largest result, and the third largest result, respectively, as the relative orientation filters having their respective distinguishing features that are closer to the distinguishing feature in the subject direction, and

distributing, using interpolation, the relative orientations specified by the selected relative orientation detection filters, thereby determining one relative orientation.

14. (Canceled)

15. (Canceled)

16. (Previously Presented) The image processor as claimed in Claim 5, wherein the relative orientations specified by the selected relative orientation detection filters are distributed using interpolation to determine one relative orientation, B, using the following equations:

$$P = K*A^2 + L*A + M;$$

$$Q = K*(A+c)^2 + L*(A+c) + M;$$

$$R = K*(A+2c)^2 + L*(A+2c) + M;$$

$$B = -L/(2*K);$$

where Q is the largest convolution result; where P and R are the second and third largest convolution results; where K, L, and M are constants; where A+c is the angle corresponding to relative orientation detection filter yielding the largest convolution result; where A is the angle corresponding to the relative orientation detection filter that yielded the result P; and where A+2c is the angle corresponding to the relative orientation detection filter that yielded the result R.